



PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Process and apparatus for Contacting Vaporized Hydrocarbons with Fluidised finely divided Solid Catalyst

We, NAAMLOOZE VENNOOTSCHAP DE BATAAFSCHE PETROLEUM MAATSCHAPPIJ, a Company organised under the laws of The Netherlands, of 30, Carel van Bylandtlaan, The Hague, The Netherlands, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to an improvement in the design and operation of reactors for contacting vaporized hydrocarbons with fluidised finely divided solid catalysts, and, in particular, to the catalytic cracking of hydrocarbon oils with fluidised cracking catalyst.

The invention relates to that type of reactors, known as the downflow type of reactors, in which the fluidised catalyst particles are withdrawn by gravity from the fluidised bed within the reactor.

In reactors for the catalytic cracking of hydrocarbon oils, the catalyst withdrawn from the reactor by gravity normally contains a considerable amount of the reactant vapours adsorbed on the particles and occluded in the moving mass. These adsorbed and occluded vapours are removed by a so-called stripping step in which the stream of solid catalyst particles being withdrawn is flushed with a stripping vapour such, for example, as steam. Stripping may be effected inside the reaction vessel as well as in a separate external stripping vessel.

Internal stripping is effected in a part of the reaction vessel zoned from the remaining part of the vessel by a partition or other suitable structure. For example, a vertical partition is extended from the bottom of the vessel upward into the fluidised bed of solid. That part of the bed to one side of the partition, and also all of the bed above the level of the top of the partition, is utilised in effecting the reaction and is known as the reaction section or reaction zone, and that part on the other side of the partition and below the level of the top of the partition constitutes the stripping zone. This system is suitable for the catalytic cracking of hydrocarbon materials, but not for such reactions

as catalytic reforming, dehydrogenation and dehydrocyclisation with dehydrogenating metal oxide catalysts, primarily because of the fact that most of the catalysts used in such processes are poisoned by water vapour. The system according to the invention is, however, also suitable for the latter type of reactions.

A much more satisfactory arrangement is to construct the stripping zone as an annular zone surrounding the reaction zone. Another more satisfactory arrangement is that in which the partition extends as a chord across the horizontal cross-section of the reaction vessel, thus creating a small stripping zone between the periphery of the vessel and the partition. These more suitable arrangements are used in the process and apparatus of the present invention.

In order to explain the nature of the improvements in the process and in the apparatus according to the present invention, the limitations hitherto existing in the reactors of the type in question will be elucidated. As mentioned above, in the downflow type of reactor, the solid is withdrawn by gravity from the fluidised bed in the reactor. The carry-over of solid with the effluent gaseous fluid is undesired and held at a minimum. The carry-over of any appreciable amount of the solid is prevented by passing the vapours through a cyclone-type separator. This separator is mounted near the top of the vessel. In order to return the separated solid to the main mass of the solid, the catalyst particles collected in the separator are withdrawn by gravity through a so-called dip leg. It is essential that provision be made to prevent gas or vapour from passing up through this dip leg. It is, therefore, essential that the bottom of the dip leg be sealed in some manner against any appreciable entrance of gas and this is usually done by utilising the liquid properties of the main mass of fluidised solid. Thus, the dip leg is caused to dip into the fluidised bed. In order to obtain a sufficient pressure to cause the separated solid to flow down the dip leg back into the fluidised bed, a dip leg of, for instance, at least about 8 feet is desirable in the usual type of apparatus. With this

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arrangement, the bottom of the cyclone separator must, therefore, be at least about 8 feet above the level of the fluidised bed.

When the height of the cyclone separator itself (which is appreciable and may be, for example, 15 feet) is added to this, it is seen that the reactor vessel must extend above the fluidised bed level by a very substantial distance, e.g. 20—30 feet. In other words, in downflow reactors of the designs hitherto used, it has been necessary to maintain the level of the fluidised bed well below the top of the reactor vessel. In a cylindrical reactor vessel, there is, therefore, a large unused volume which, if it could be utilised, would accommodate a much larger fluidised bed.

This limitation is removed in the process of the invention by discharging the separated catalyst particles from the cyclone-type separator by gravity flow into a further fluidised bed of the finely divided solid catalyst, the level of which is lower than the level of the fluidised bed in the reaction zone.

Accordingly, the present invention provides a process for contacting vaporized hydrocarbons with fluidised finely divided solid catalyst which comprises contacting the vaporized hydrocarbons with a fluidised bed of the finely divided solid catalyst, separating the catalyst particles, entrained by the vapours flowing into the space above the said fluidised bed, from the vapours by means of a cyclone-type dust separator and discharging the separated particles by gravity flow from the said separator into a further fluidised bed of the finely divided solid catalyst, the level of which is lower than the level of the first-mentioned fluidised bed.

The invention is particularly applicable to a process for the vapour phase catalytic cracking of a hydrocarbon oil, in which the fluidised solid catalyst is continuously circulated through a reaction zone, a contiguous stripping zone and a separate regeneration zone, and is passed from the fluidised bed in the reaction zone by overflow over a weir into the stripping zone. When applied to such a process the invention may be carried out by maintaining a high bed level in the reaction zone and a low bed level in the stripping zone, and passing the catalyst particles, separated by the cyclone-type separator, by gravity flow from the said separator into the fluidised bed in the stripping zone, the level of the fluidised bed in the reaction zone being above the maximum level which allows said separated catalyst to flow by gravity directly from said separator to the reaction zone and the level of the fluidised bed in the stripping zone being sufficiently below said maximum level to allow the separated catalyst to flow from said separator into the fluidised bed in the stripping zone.

In order to carry out the above process, it is necessary to pass the dip leg of the cyclone separator through the partition which separates the stripping zone from the reaction zone. It then becomes possible to greatly extend the height of the partition to within a short distance of the inlet openings of the cyclone separator. The level of the fluidised bed in the reaction zone is, therefore, increased and this large additional volume becomes utilisable.

The invention also provides an apparatus for the catalytic cracking of vaporized hydrocarbons comprising a reaction vessel, a substantially vertical partition dividing the major volume of the reaction vessel into at least two separate compartments, a reaction zone and a stripping zone, which compartments communicate only above the top of said partition, said partition extending upwards from the effective bottom of said vessel to a point well above the centre of the vessel, but below the inlet ports of a cyclone-type dust separator located near the top of said vessel, a line for removing separated catalyst by gravity flow from the said separator, said line depending from said separator and extending through said partition to discharge in the said stripping zone at a point below the top of said partition, and means for maintaining the level of the bed of fluidised catalyst in the stripping zone below that of the bed of fluidised catalyst in the reaction zone.

The apparatus may, of course, be fitted with a plurality of cyclone separators. When this is so, the separators will normally discharge the separated catalyst particles into a common line leading to the stripping zone.

It will be seen from the above that in the apparatus according to the invention the stripping zone is within the reactor vessel and is located at the outside horizontal periphery of the reaction zone. The cyclone dip leg passes through the partition which separates the reaction zone from the contiguous stripping zone and discharges into the fluidised bed in the stripping zone. The fluidised bed in the stripping zone is retained at a low level, thereby allowing the separated solid to pass through the dip leg into the stripping zone and, at the same time, affording the increased efficiency of the stripping step. The height of the partition is increased materially thereby, increasing materially the height of the fluidised bed in the reaction zone and the amount of solid that a reactor of given external dimensions can profitably utilise.

The advantages which can be gained by applying the improvements of the invention are as follows. The efficiency of the stripping step is materially increased. For a reactor of given throughput capacity, the

height and/or diameter may be materially decreased. This not only represents a large saving in capital cost for the vessel itself, but also in the supporting structure. On the other hand, with a given reactor the throughput capacity may be increased markedly, in some cases twofold. Moreover, by decreasing markedly the vapour space above the fluidised bed in the reactor, the secondary reactions which normally take place in this space are materially reduced.

The invention is further described with reference to the diagrammatic illustrations in the accompanying drawing.

Referring to the drawing, Figure I is a flow diagram in which are indicated the essential relative levels of the fluidised beds in the reaction zones and stripping zones and the positions of the cyclone separators and their dip legs. Figures II and III are diagrammatic illustrations of alternative ways of partitioning the vessels to provide suitable stripping zones and reaction zones.

Referring to the drawing, Figure I, a cracking vessel 2 and regeneration vessel 1 are diagrammatically indicated. These vessels may be of different size and/or design. The reaction zones are separated in each case from their corresponding stripping zones by a partition 3 which extends across the cross-sections of the vessels as chords. Thus, as illustrated in Figure II, the smaller section on the left hand is the stripping zone and the larger section on the right is the reaction zone. An alternative is illustrated diagrammatically in Figure III. Here the reaction zone is centrally located and the stripping zone is in the form of an annular zone surrounding the reaction zone.

As illustrated in Figure I, the cyclone separators 4 are built within the vessel and are placed at the top. Two-stage cyclone separators of the conventional design are diagrammatically indicated. Vapours carrying suspended solids enter the first stage of the cyclone separators by tangential inlets 5 and, after passing through the two stages, the vapour is discharged by line 6 substantially free of suspended particles. The powder separated in the two stages in the cyclones collects in the conical section 7 of the cyclones and is continuously withdrawn by gravity through dip leg 8. Dip leg 8 passes through the partition 3 and discharges into the stripping zone at a low level. As previously indicated, this dip leg must be sufficiently long to cause the separated powder to flow by gravity; from practical experience the minimum length is known to be about 8 feet.

In reactors of the conventional design, i.e., with the cyclone dip leg discharging in the reaction zone, the maximum level of the

fluidised bed of catalyst in the reaction zone would be approximately as indicated by the broken lines A, and the partitions 4 would end at this level. By passing the cyclone dip leg 8 through the partition into the stripping zone and holding the level of the fluidised bed in the stripping zone at a low level (below A), the partition 3 can be extended at least 5 feet and, if desired, to within two or three feet of the cyclone inlets. Thus, the level of the fluidised bed can be raised until it actually covers the lower parts of the cyclone separators. The increased volume of fluidised catalyst bed that therefore is made available is indicated in the drawing by the cross-hatched section of the fluidised bed above the broken line A. The spent catalyst continuously overflows the top of the partition and in doing so rains down to the fluidised bed in the lower section of the stripping zone. This feature improves the stripping efficiency.

The operation of the system illustrated is otherwise conventional. Thus, steam or other suitable stripping gas is introduced near the bottom of the stripping sections by lines 9 and 10. Stripped catalyst is withdrawn from the respective vessels by standpipes 11 and 12 and, after passing through control valves 13 and 14, are picked up and carried to the reaction section of the opposite vessel by air and oil introduced by lines 15 and 16, respectively. The mixtures are discharged over the cross-sections of the respective reaction zones by means of gas distribution means such as grids, indicated in the drawing by the broken lines 17 and 18.

The path of the main mass of catalyst starting at the control valve 14 is, therefore, as follows: hot, freshly regenerated catalyst is picked up by oil and carried by line 19 as a dilute suspension into the dense phase bed of catalyst in the reaction zone of the cracking vessel. After becoming partially spent in the reaction zone, the powdered catalyst overflows the top of the partition 3 and, after falling as a dilute phase countercurrent to uprising vapours of stripping gas, it collects in a low level, dense phase bed in the stripping zone. Here it is stripped of adsorbed hydrocarbons by steam introduced by line 9. The spent and stripped catalyst descends as a dense phase by gravity through the standpipe 11 and control valve 13 and is picked up by air and carried as a dilute phase in line 20 to the dense phase bed in the regeneration vessel. After being regenerated in the dense bed, the catalyst overflows the top of the partition and falls as a dilute phase to the dense phase low level bed in the stripping zone of the regenerator. Inert gas or steam is introduced at the bottom of the stripping zone by line 10. The regener-

ated catalyst stripped of occluded oxygen is withdrawn as a dense phase by the stand-pipe 12 to complete the cycle.

5 A minor amount of the catalyst is thrown up above the level of the dense catalyst phase in the respective reaction zones. Most of this catalyst falls back into the dense phase bed and overflows the partition as described. However, some remains suspended
10 in the dilute phase above the catalyst bed. This material is separated from the vapours by the cyclone separators and is returned to the catalyst mass in the dense phase bed in the stripping zone by means of the dip leg 8.
15 In operation it is essential that the fluidised bed of catalyst in the stripping zone be maintained at a low level which is considerably below the level of the top of the partition. If for any reason the level in this zone
20 should be allowed to rise to the top of the partition, the cyclones would cease to function and the process would become inoperative. In practice it is, therefore, essential that suitable safeguards be provided for
25 automatically controlling the level of the fluidised bed in the stripping zone.

What we claim is:—

1. A process for contacting vaporized hydrocarbons with fluidised finely divided
30 solid catalyst which comprises contacting the vaporized hydrocarbons with a fluidised bed of the finely divided solid catalyst, separating the catalyst particles, entrained by the vapours flowing into the space above the said
35 fluidised bed, from the vapours by means of a cyclone-type dust separator and discharging the separated particles by gravity flow from the said separator into a further fluidised bed of the finely divided solid catalyst,
40 the level of which is lower than the level of the first-mentioned fluidised bed.

2. A process as claimed in Claim 1, wherein the finely divided solid catalyst is a cracking catalyst.

45 3. A process for the catalytic cracking of vaporized hydrocarbons as claimed in Claim 2, wherein the fluidised finely divided solid catalyst is continuously circulated through a reaction zone, a contiguous stripping zone
50 and a separate regeneration zone, and is passed from the fluidised bed in the reaction zone by overflow over a weir into the strip-

ping zone, and wherein a high bed level is maintained in the reaction zone and a low
55 bed level in the stripping zone, and the catalyst particles, separated by the cyclone-type separator, are discharged by gravity flow from the said separator into the fluidised bed in the stripping zone, the level of the fluidised bed in the reaction zone being above the
60 maximum level which allows said separated catalyst to flow by gravity directly from said separator to the reaction zone and the level of the fluidised bed in the stripping zone being sufficiently below said maximum level
65 to allow the separated catalyst to flow from the said separator into the fluidised bed in the stripping zone.

4. Apparatus for the catalytic cracking of vaporized hydrocarbons comprising a reaction
70 vessel, a substantially vertical partition dividing the major volume of the reaction vessel into at least two separate compartments, a reaction zone and a stripping zone, which compartments communicate only
75 above the top of said partition, this partition extending upward from the effective bottom of said vessel to a point well above the centre of the vessel but below the inlet
80 ports of a cyclone-type dust separator located near the top of said vessel, a line for removing separated catalyst by gravity flow from the said separator, said line depending from
85 said separator and extending through said partition to discharge in the said stripping zone at a point below the top of said partition, and means for maintaining the level of
90 the bed of fluidised catalyst in the stripping zone below that of the bed of fluidised catalyst in the reaction zone.

5. Apparatus as claimed in Claim 4, in which the reaction zone is centrally located in the reaction vessel and the stripping zone is in the form of an annular zone surrounding the reaction zone.

95 6. A process for contacting vaporized hydrocarbons with fluidised finely divided solid catalyst and apparatus therefore substantially as hereinbefore described with reference to the accompanying drawing.

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COMPLETE SPECIFICATION

1 SHEET

This drawing is a reproduction of
the Original on a reduced scale.

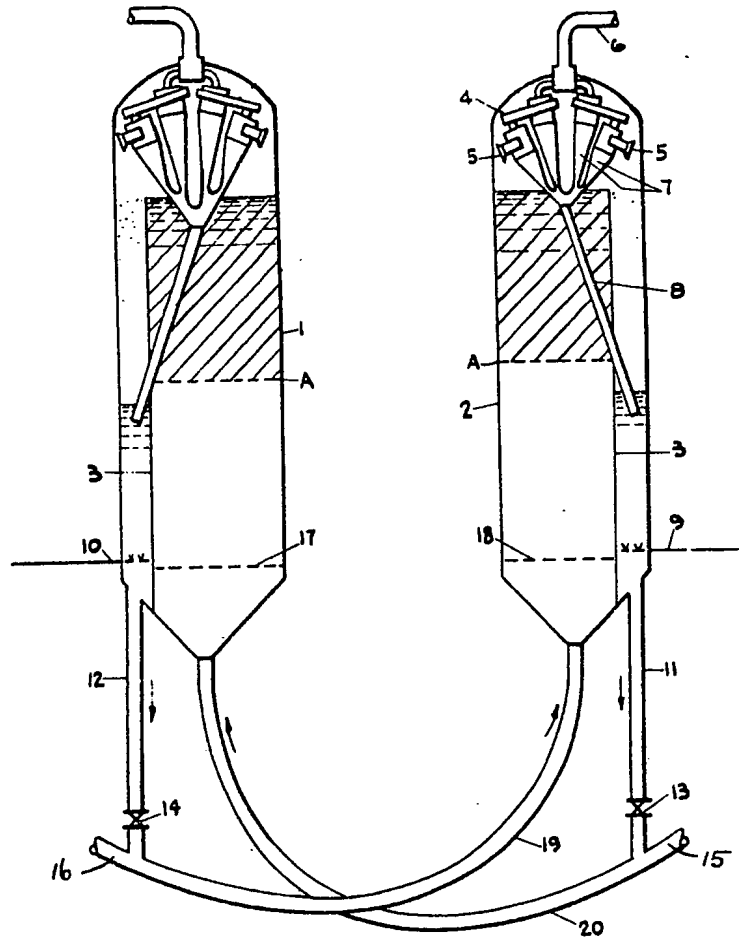


Fig. I

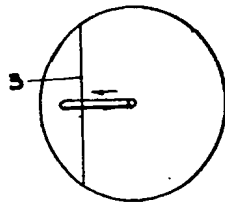


Fig. II

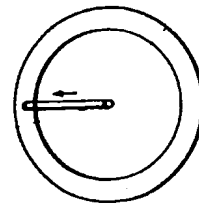


Fig. III